# FIRE LOSSES IN DIFFERENT OCCUPANCIES AND BUILDING TYPES

Report 4/78
Fire Research

Home Office

S. Gilbert
R. Rutstein

Scientific Advisory Branch

HOME OFFICE SCIENTIFIC ADVISORY BRANCH

REPORT NO. 4/78

FIRE RESEARCH

# FIRE LOSSES IN DIFFERENT OCCUPANCIES AND BUILDING TYPES


## SUMMARY

Estimates of the average fire losses and total fire losses in different types of buildings and industries have been calculated for the years 1970 to 1974. These estimates are derived from the BIA figures for large loss fires, using a statistical technique developed by SAB. Estimates of total annual fire loss in several industrial groups have been compared with the asset values of these groups to provide a measure of the relative seriousness of the fire problem in different industries. Approximately 0.1% of all industrial assets are estimated to be destroyed by fire each year.

Losses due to different sources of ignition have also been estimated. However, due to the large number of fires with unknown cause the accuracy of these loss figures is limited.


January 1978


Prepared by:

S GILBERT

R RUTSTEIN

Approved by:

S F J BUTLER

CONTENTS PAGE


1. INTRODUCTION 1

2. THE ESTIMATION OF AVERAGE LOSSES

2.1 The Classification of Fires 2

2.2 The BIA Losses 4

2.3 Method of Estimating Average Losses 5

3. LOSSES IN DIFFERENT CLASSES OF BUILDINGS

3.1 The 32 Group Classification 7

3.2 The Validity of the Estimates 8

3.3 Storage and Non Storage Losses 9

3.4 Longer Term Trends 10

4. THE MAGNITUDE OF THE FIRE PROBLEM

4.1 The Asset Value of an Industry 11

4.2 Total Fire Losses Compared to Asset Values 12

5. TOTAL LOSSES DUE TO DIFFERENT SOURCES OF IGNITION

5.1 Fires with Unknown Causes 13

5.2 The Effect of Fires with Unknown Causes on the Loss Figures 13

5.3 Discussion 14

6. COMPARISON WITH OTHER WORK 15

7. SUMMARY OF FINDINGS 17

References 18

APPENDIX A - Manual Method of Calculating Asset Values 29

APPENDIX B - Method of Assessing Industrial Asset Values 32

## TABLES AND FIGURES


| | | PAGE |
|---|---|---|
| Table 1 | The 32 Classes of Building | 19 |
| Table 2 | Building Regulation Groups | 20 |
| Table 3 | Average Direct Fire Losses | 21 |
| Table 4 | Total Direct Fire Losses | 22 |
| Table 5 | Yearly Loss Totals compared to BIA Estimates | 23 |
| Table 6 | Average Direct Losses Due to Fire in Storage and Non Storage Premises | 24 |
| Table 7 | Total Losses compared to Asset Values | 25 |
| Table 8 | Losses by Cause of Ignition | 26 |
| Table 9 | Estimates of Average Losses in the Textile Industry produced by Ramachandran's Method and the SAB Method | 26 |
| Table A.1 | The Hazard Function | 31 |
| Figure 1 - | The Definition of Building Classes in terms of SIC and Building Regulation Groups. | 27 |
| Figure 2 - | Annual Total and Average Losses Due to Fire 1965-1976. | 28 |

## 1. INTRODUCTION

The only generally available information on United Kingdom fire losses is produced and published by the British Insurance Association (BIA). The BIA publish estimates of total fire losses each month, and also provide estimates of the losses in individual large fires in which the loss exceeds a certain limit.* No information is published on total, or average, fire losses in different types of buildings or different classes of fires.

A statistical study has therefore been undertaken to fill this gap and produce estimates of the losses in different categories of fires. The estimates of average and total losses are based on the available BIA data. The results of the study presented in this report cover the years 1970 to 1974.

* In the years up to 1973 the lower limit for 'large' fires was £10,000. It was raised to £15,000 in 1974 and has since been increased further.

## 2. THE ESTIMATION OF AVERAGE LOSSES

### 2.1 The Classification of Fires

Fires can be classified in various ways, depending on the purpose of the enquiry or the interests of the enquirer. The buildings in which the fires occur are usually classified according to the sector of industry (as defined by the Standard Industrial Classification, SIC), or according to the usage of the building (as defined by the Building Regulations).

While both these methods of classification may be useful in particular circumstances, they can have disadvantages. For example, an average loss figure for the Chemical Industry (as defined by SIC) would include fires in all parts of the industry. Fires in very different situations, in refineries, in storage facilities, or in the London Head Offices, would be included. On the other hand an average loss figure for, say, the Building Regulations subgroup covering industrial premises would include all premises where processing, manufacture or repair is carried out, from chemicals and petroleum to textiles and footwear.

In order to produce the most useful general picture of losses a composite classification has been used in the main analysis in this report, based on both the industry and the usage of the building. The purpose of this classification is to identify classes of buildings (or other premises or property) in which the circumstances are broadly similar. For example, all offices are considered as one group, while the factories in each different industry are considered as separate groups.

There are some classes where it is appropriate to group fires in outdoor plant, outdoor storage or other outdoor locations together with the building fires in order to provide a better picture of the group as a whole. We have been able to do this in some cases, but in other cases, although we could see the need to include some outdoor fires it was not possible to determine exactly which outdoor fires should be included. For example, some fires in road

vehicles should be considered as losses in the Transport industry, but other road vehicles will belong to specific industries. Road vehicles have therefore not been included in any of the main groups.

The outdoor fires which have been grouped with building fires are fires in crops and farm machinery which are included in the Agricultural class; fires in outdoor plant which are included in the Chemical industry, Mining and Petroleum, or Gas and Electricity; and fires in ships, boats and trains which are included in the Transport industry.

The 32 classes used are shown in Table 1. The relationship between these classes and the SIC and usage groups is shown in Figure 1 and Table 2.

Included in the analysis are all United Kingdom fires, in and out of buildings, which were attended by the fire brigade and where there was damage to property (ie all fires for which a K433 fire report was completed). Fires not in buildings are those in outdoor plant and storage, in vehicles of all kinds and on farm land where there was damage to crops. The fires excluded are those classed as minor fires in the Annual United Kingdom Fire and Loss Statistics. These include fires in derelict buildings, trees, refuse, grassland and other "small" hazards. The total losses involved in such fires are assumed to be insignificantly small.

No single classification of fires can provide all the information that might be of interest. In particular, it may be useful to identify the losses due to fires in industrial storage buildings separately from those in buildings associated with production. A second analysis of fires in industrial building was therefore undertaken. Fires in buildings in the usage group 'storage' were separated out from the industrial groups used in the first analysis and averag losses calculated for 'storage' and 'non-storage' classes.

Finally, an investigation was made into fires classified by source of ignition. The proportions of total fire losses due to some major causes were calculated, and the effect of fires with unknown causes investigated.

## 2.2 The BIA losses

The figures presented in this report are based on the BIA statistics as these are the only large scale source of fire loss information available. If these figures are to be used in a quantitative economic study it is important to understand their basis, so that a meaningful comparison with other monetary information may be made. The interpretation of the BIA loss figures described here represents our understanding of them. These views are based on discussion with the BIA, and with directors or accountants of firms which have had fires and claimed insurance.

The BIA figures are estimates of the direct loss incurred in fires. That is, they represent the total cost of the physical assets destroyed as assessed by the insurance company's staff, or by a loss adjuster instructed by the insurance company. The full loss in any fire would always be assessed and used for the purposes of the BIA loss estimates whether or not the claimant was fully insured. However, the method of assessing the loss would depend on the terms of the insurance policy held. The policy could be an indemnity policy or a full reinstatement policy. In the case of an indemnity policy only the depreciated value of the destroyed items would be recorded. Under a full reinstatement policy the claim would be made for the cost of replacing damaged or destroyed assets with equivalent new items, or repairing them to new condition.

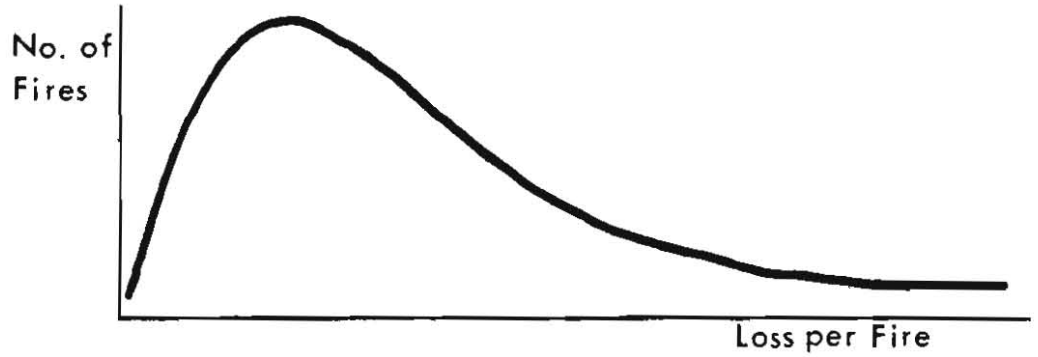
The loss recorded for a fire will therefore depend on the type of insurance policy covering the premises involved. There is considerable variation in the way in which assets are insured. However, from our discussions it appears that industrial buildings and major items of plant are often insured for full replacement cost; less essential items being insured only on an indemnity basis.

The published large loss figures represent the assessors first estimate of the loss. This is only a preliminary figure, and may be changed when the claim has been fully examined. However, no systematic error in these estimates is expected so, when a number of fires are considered, any errors should average out. A fairly reliable aggregate figure can therefore be obtained.

2.3 Method of Estimating Average Losses

Essentially, the method consists of examining the known large losses and extrapolating these back to obtain an estimate of the losses due to small fires. An overall estimate of the losses is then obtained by combining the estimated small losses and the known large losses.

To use this method some assumption about the distribution of the size of losses in fires needs to be made. It is known that there is a large number of fires where losses are small and a very small number where losses are large. For example, in 1973 large fires represented about 1% of the total number of fires, although they accounted for around 60% of the total fire loss. A convenient statistical distribution often used to describe this situation is known as the log-normal distribution, the general shape of which is shown below.




The exact shape of this distribution depends on the values of two parameters. These may be estimated from the available information on

large fires. Once these values are known the average fire loss over the whole distribution may be calculated. A convenient manual method for deriving estimates of average fire losses is described in Appendix A.

## 3. LOSSES IN DIFFERENT CLASSES OF BUILDINGS

### 3.1 The 32 Group Classification

Using the method outlined in section 2.3 the annual average fire losses for the 32 groups shown in Table 1 were calculated for the years 1970 to 1974. The results of these calculations are shown in Table 3. The retail price index was used to convert the yearly figures to 1976 price levels for comparison purposes.

It can be seen from the table that the greatest average loss is experienced in the Electrical Engineering industry. Over the 5 year period the fire loss averages out at approximately £22,000 per fire. This is far greater than the average £1,700-£1,800 in all fires. The high loss may reflect the expensive nature of many of the goods (computers, radio and TV etc) produced in this industry.

In fact, most industrial groups show losses much higher than the overall average. This is because other groups such as private houses, where the average loss is low, account for a very large proportion of all fires. This obviously affects the average over all fires and produces a figure which at first sight appears low. Considering manufacturing industry alone, a typical figure for loss per fire is around £8-10,000.

Groups 9, 10, 12, 28, 29 (and 32) include fires not in buildings as well as building fires. While this gives a truer indication of the average loss in these industries the inclusion of many small out of building fires makes comparisons with losses in other industries misleading. The effect of the out of building fires is greatest in the agriculture group where, if building fires alone were considered, average losses would increase (from £2100 to £2900 in 1973 for example.)

## 3.2 The Validity of the Estimates

The average losses given in Table 3 may be used to produce estimates of the total annual fire loss in each class. These losses are shown in Table 4.

Total losses reflect the number of fires in each group as well as the average loss per fire. So some groups that were shown to have low average losses, such as private houses (approximately £400) or pubs and restaurants (about £2,500), but have a large number of fires, in fact have a large total annual loss (around £20 million and £13 million respectively). Most industries, despite high average losses, experience moderate overall losses as the number of fires each year is relatively small.

Of the £217-275 million losses each year, the largest proportion (£25-30 million) is accounted for by fires in transport and distribution industries. In this industry group there are many warehouse fires which result in high losses.

As already mentioned the BIA publishes annual estimates of the total fire loss in the United Kingdom. A comparison of these figures with the estimated total losses for all groups (found by summing the estimates given in Table 4) is shown in Table 5.

There are two possible reasons for discrepancies between our estimates of total fire losses and the BIA estimates. Firstly, there are errors in our estimates, due to the statistical methods used to obtain the overall figures from the large loss information. Secondly, the BIA estimates include losses in fires not reported to the brigades, and so not included in our analysis. If the estimating errors are small our estimates should be close to, but slightly less than, the BIA figures.

Table 5 shows our estimates of fire loss are reasonable, and consistent with the total figures published by the BIA. Theoretical studies [1] also indicate that the method used can be expected to provide reasonable results.

### 3.3 Storage and Non Storage Losses

In industrial groups a distinction can be made between buildings used for storage and buildings used for actual manufacture, assembly, processing or repair purposes. It may be useful to break down the fire losses for industry groups given in Table 3 into losses in storage and non-storage premises.

Information on large losses in storage premises can simply be found by considering losses in the Building Regulations group 'Storage' for each industry. Non-storage losses are those for the whole industry less these storage losses and losses in offices.

In principle then a complete breakdown between storage and other losses for each industry group shown in Table 1 can be obtained. However, as there are very few large loss storage fires in most industries the statistical methods employed in this study cannot be used on individual groups.

Estimates have been produced for several wide industrial groupings and for industry as a whole. These are shown in Table 6. Despite annual variations the table shows that for all industry average losses in fires in storage buildings are considerably higher than in non-storage buildings; this is a reflection of the larger fire size in storage premises (as fewer people may be around to detect fires before they develop), the more rapid spread in storage premises where fire loading may be high, and the higher value per area where goods may be kept in high rack storage.

## 3.4 Longer Term Trends

To obtain a clear picture of the trends in annual and average fire losses a longer period than the 5 years considered in this report needs to be examined. There is much random variation in the annual fire loss figures and over a short time period this may mask the underlying trends.

As an indication of what might be expected in the longer term Figure 2 shows annual total and average fire losses (at constant prices) for the years 1965 to 1976. The total loss figures shown are BIA estimates for England, Scotland and Wales. Average loss figures have been found by dividing the BIA losses by the total number of fires each year as published in the annual fire statistics. It should be noted that these figures are not comparable with other figures in this report, which are for the whole of the United Kingdom including Northern Ireland.

Figure 2 shows there is considerable variability in the yearly figures, those for 1973 standing out as being particularly high. For the period from 1965 average losses show no trend and total losses increase by about 2% per year over the period. The number of fires per year also increases, accounting for the increasing total losses.

## 4. THE MAGNITUDE OF THE FIRE PROBLEM

Care must be taken in drawing conclusions from the average loss and total loss figures for different classes of fires. Both these figures can be misleading.

The average loss figure is affected by the policy towards reporting fires to the brigade. For example, the brigade are usually called to all fires in hospitals, and hence there is a large number of reported small fires in this class; this reduces the average fire loss for all reported fires. If, in some classes of fires, the fires are dealt with by employees or works fire brigades without the public fire brigade being called, then there are few reported small fires and the average fire loss is high.

Total fire loss figures are not greatly affected by the reporting rate as the unreported fires are unlikely to involve very large losses. They can however also be misleading if not interpreted carefully. The total losses in a particular industry may be large simply because the industry itself is very large.

To appreciate the extent of the fire problem in different sectors of industry the fire losses should be set in a proper context. The estimated fire losses are a measure of the physical assets destroyed by fire. It is therefore proper to compare direct fire losses with the total value of the assets in each class of buildings. This then provides a measure of the proportion of the assets of each industry which is destroyed each year by fire. This measure can then be used to compare the relative seriousness of the fire problem in different industries, whether the industries are large or small.

### 4.1 The Asset Value of an Industry

Information on the stock of capital assets in the United Kingdom is published by the Central Statistical Office in the National Income and Expenditure Accounts.[2]

In the National Accounts assets are divided up according to fairly broad SIC industrial groupings. Fire losses must therefore also be calculated over the same broad groupings, ignoring usage, in order to make them comparable.

If valid comparisons are to be made it is also important that the loss figures and the asset values are measured in the same way. The loss figures are based on BIA estimates, which are described in Section 2.2. Comparable asset values are found by taking the gross capital stock value for buildings and adding it to the net capital stock value for vehicles, plant and machinery and stocks. Details of the method of assessment of asset values are included in Appendix B.

## 4.2 Total Fire Losses Compared to Asset Values

The asset values, found as above, were compared to the total annual fire losses and the percentage of assets destroyed by fire calculated. This is shown in Table 7. Approximately 1/10th of 1 per cent of all industrial assets are destroyed by fire each year. Proportionately more assets are destroyed in the Textiles, Clothing and Manufacturing industries where there are many high risk areas. Metal Manufactures industry has a lower loss, possibly to do with the non-flammable nature of much of the stock.

## 5. TOTAL LOSSES DUE TO DIFFERENT SOURCES OF IGNITION

The Annual Fire and Loss Statistics include information on the source of ignition of all fires. These data may be used to estimate the total fire losses due to different causes using the statistical methods already described.

### 5.1 Fires with Unknown Causes

Problems are caused by the large number of fires recorded as having an unknown source of ignition. A very high proportion of large fires is recorded as "unknown" (46% in 1973, compared with a figure of 11% for all fires). Such a high proportion of unknowns may seriously affect the calculation of the losses due to different causes. The fires with unknown causes cannot be ignored or treated separately. Fires classified as having an unknown cause are not a separate kind of fire, so each fire should be assigned to its true cause. If this is not done, the loss values obtained may considerably underestimate the importance of some causes.

Unfortunately there is no way of estimating the actual cause of any fire recorded as having an unknown cause. Any method of assigning these fires must be arbitrary and therefore possibly subject to large errors.

One method of assigning the unknown fires is to split them up into known causes in proportion to the number of fires known to be due to each of these causes. This method may lead to errors; for example, some causes which may be more difficult to detect than others would be more than proportionately represented in the unknown fires.

### 5.2 The Effect of Fires with Unknown Causes on Loss Figures

In order to investigate the possible errors due to any assumptions about the assignment of the unknowns, two theoretical cases were investigated. These were

designed to represent extreme, but plausible, distributions of the unknowns. By comparing the loss figures obtained in the two extreme cases, an estimate of the range within which the true loss could lie was obtained. The two extreme cases chosen were:-

1. No unknown large fires assigned to each cause, ie large fires recorded as unknown are excluded.

2. A large proportion of the unknowns assigned to each cause. (This proportion being 1.5 times the proportion of the fires with known cause due to each cause).

In both cases small fires were assigned proportionately.

## 5.3 Discussion

Total losses in 1970 due to several important causes of fires in buildings are shown in Table 7. The losses are expressed as a percentage of the total loss due to all causes. Values are given for the two extreme cases and also an intermediate case with the large unknowns assigned proportionately.

The figures show that the loss value obtained is sensitive to the method of assigning the unknown fires. The range within which the true value of the loss may lie is so wide that it would be unwise to quote loss figures based on any assumed distribution of the unknown fires. However, a rough order of importance and relative size of loss can be obtained from the results. For example, the loss in malicious/doubtful fires, of between 12 and 30% of total, is larger than the loss in fires caused by children with fire (3.4 to 8.7% of total), despite there being more fires due to the latter cause. Fires due to smoking materials produce a greater loss (5.6 to 13.7% of total) than those due to children with fire. Fires due to electrical and gas equipment are the least important of the groups considered, electrical wiring (4.4 to 10.5%) accounting for the highest losses.

## 6. COMPARISON WITH OTHER WORK

Ramachandran [3-5] has also developed a method of calculating average fire losses from large loss data. The method assumes a log-normal distribution of size of loss and uses a weighted least squares estimation process. To use this method details of the losses in individual large fires need to be known. Average fire losses found by this method for various industrial classes are presented by Rogers [6] as part of a study of losses in sprinklered and non-sprinklered buildings.

The average loss figures presented by Roger appear at first sight to vary considerably from figures produced for almost identical industrial groups in this report. However, if the two sets of figures are examined closely it becomes clear that they in fact relate to two different situations. The average losses given in this report are averages for all fires reported to the fire brigades (excluding minor fires not in buildings). Rogers produces figures for the average loss in all fires (reported or otherwise) which developed beyond the small stage (See section 3, reference 6). This would appear to be the major source of variation between the two estimates.

The estimates of the total losses should be less sensitive to the differences in definition. Table 9 shows a comparison of the estimates produced by the two different methods for fires in the textile industry. There is a close agreement between the two sets of estimates.

It can thus be seen that the estimation methods used by Ramachandran and by the Scientific Advisory Branch produce very similar answers once the differences in definition of the sample of fires is taken into account.

## 7. SUMMARY OF FINDINGS

The findings of this report are shown in the following tables. When using these tables, care should be taken to ensure that the definitions of the building or industry groups are fully understood. This is especially important in tables 3 and 4, where the group labels used may be more general than they appear at first. For example, the 'Hospital' group includes nursing homes and old people's and children's homes as well as hospitals. Tables 1 and 2 should clear up most points.

From the tables some overall conclusions may be drawn as regards the pattern of fire loss for the years dealt with:

1. Average loss per fire in manufacturing industry is of the order of £8-10,000, average losses per fire in offices, shops and hotels are between £3,000 and £4,000, and average losses per fire in private houses are about £400.

2. Total annual losses in transport and distributive buildings (£25-30 million pa), shops and private houses (both approximately £20 million pa) are the largest contributors to annual fire losses.

3. The average loss due to fire in industrial storage premises is considerably larger than that in non-storage premises.

4. Approximately 0.1% of the assets of industry are destroyed by fire each year.

REFERENCES

1. Rutstein, R
A Comparison of Three Methods of Estimating the Mean of a Log-Normal Distribution Using a Sample of Censored Data. Home Office, SAB Memorandum No 8/77.

2. National Income and Expenditure 1965-1975 Central Statistical Office.

3. Ramachandran, G. Some Possible Applications of the Theory of Extreme Values for the Analysis of Fire Loss Data. Fire Research Station, Fire Research Note 837 Borehamwood 1970.

4. Ramachandran, G. Extreme Value Theory and Fire Losses Further Results Fire Research Station Fire Research Note 910 1972.

5. Ramachandran, G. Extreme Value Theory and Large Fire Losses. Astin Bull. 1974 VII (3) 293-310.

6. Rogers, F E. Fire Losses and Effect of Sprinkler Protection of Buildings in a Variety of Industries and Trades. FRS Current Paper CP9/77 1977.

TABLE 1

THE 32 CLASSES OF BUILDINGS

| Group | Major Risks Included | Description | SIC Class | Building Regulations Groups |
|---|---|---|---|---|
| 1 | Schools | All school premises | 872 | All |
| 2 | Offices | All offices except school offices | 1-909 (except 872) | Commercial 1 |
| 3 | Hospitals | Hospitals, nursing homes, childrens and old peoples homes | 701-909 (except 872) | Residential Institutional |
| 4 | Shops | All shops, except in schools or selling food for consumption on premises | 701-909 (except 872,885 | Commercial 2 Shopping Arcades |
| 5 | Pubs, Restaurants Clubs | Pubs, cinemas, theatres, restaurants, fish & chip shops, clubs, halls of all types, clinics grandstands and stadiums | 701-909 (except 872) 885 | Assembly 1, 2, 3 Commercial 2 & Shopping Arcades |
| 6 | Hotels Boarding Houses | All residential clubs hotels etc. | 701-909 (except 872) | Residential |
| 7 | Private Dwellings | Private houses, flats and maisonettes, and dwellings as part of other occupancy | - | All |
| 8 | Miscellaneous Non Industrial | Non residential private occupancies Derelict and unoccupied property Ancillary buildings on camp sites Unknown occupancies | - | All |
| 9 | Agriculture | Agriculture, horticulture, forestry and fishing | 1-100 | All except Commercial 1 |
| 10 | Mining & Petroleum | Mining, natural gas, petroleum, manufactured fuels, oils, greases etc | 101-210 261-270 | " |
| 11 | Food | Food, drink, tobacco | 211-260 | " |
| 12 | Chemicals | General chemicals, pharmaceuticals, paint, dyes, soap, toilet preps etc | 271-299 | " |
| 13 | Metal Manufactures | Iron & steel, iron casting, alloys | 300-330 | " |
| 14 | Mechanical Engineering | Industrial & office machinery etc | 331-250 | " |
| 15 | Instrument Engineering | Photographic, scientific, surgical etc | 351-360 | " |
| 16 | Electrical Engineering | Radio, Telephone, Computer etc | 361-369 | " |
| 17 | Ship building | Ship building & Marine Industry | 370-379 | " |
| 18 | Vehicle Manufacture | Motor vehicle, cycle, railway equipment, aerospace industries | 380-389 | " |
| 19 | Metal Goods | Hand tools, cutlery, jewellery, cans, wire etc | 390-410 | " |
| 20 | Textiles | Man made & natural fibres, lace, carpets, rope, twine etc | 411-430 | " |
| 21 | Leather | Leather, leather goods fur | 431-440 | " |
| 22 | Clothing | Clothes, footwear, hats | 441-460 | " |
| 23 | Bricks | Bricks, Pottery, Glass, Cement | 461-470 | " |
| 24 | Timber | Timber, Furniture, upholstery, wooden containers | 471-480 | " |
| 25 | Paper | Paper and Board, Stationery, Printing | 481-490 | " |
| 26 | Other Manufacturing | Rubber, linoleum, brushes, toys etc | 491-499 | " |
| 27 | Construction | Erecting & Repairing buildings etc | 500-600 | " |
| 28 | Gas, Electricity Water | Production and Distribution | 601-700 | " |
| 29 | Transport and Distributive Trades | Rail, road, sea and air transport industries. Posts & telecommunications storage, wholesale, retail & bulk dealers. (NB Shops excluded) | 701-859 | Industrial, Storage Miscellaneous |
| 30 | Miscellaneous Service Industries | Laundries, Dry cleaners, repairers, photographers, recording studies caterers etc | 881-900 | " |
| 31 | Public Administration | Public Administration, local government services & storage and all professional services - accountancy, legal R & D, Insurance, banking etc | 860-870 871, 873-880 901-909 | " |
| 32 | Miscellaneous Not In Buildings | All fires outside buildings not assigned to another group | - | - |

Note Groups 9, 10, 12 and 28 include outdoor plant, storage etc.
Group 29 includes ships, boats and trains.

TABLE 2

BUILDING REGULATION SUBGROUPS
(from Building Research Establishment Note "Code List for Main Fire Cards 1973")

| Building Regulations Subgroup | Premises Included |
|---|---|
| Commercial 1 | Offices, blocks of offices attached to other establishments |
| Residential | Residential Clubs, colleges and schools<br>Residential ecclesiastical buildings<br>Hotels, motels, hostels, lodging/boarding houses. Public houses with residential accommodation attached. |
| Residential Institutional | Childrens homes, old peoples homes.<br>Hospitals, private nursing homes, sanatoria, special schools for the handicapped |
| Commercial 2 | Shop premises, television, film and radio studios, laboratories |
| Shopping Arcades | Shopping Arcades and covered markets, residential property within shopping complexes |
| Assembly 1 | Passenger stations, grandstands, stadiums |
| Assembly 2 | Non-residential clubs, oolleges, schools and ecclesiastical buildings. Meeting houses, clinics and public houses |
| Assembly 3 | Theatres, cinemas, radio and TV studios to which the public are admitted. Concert halls, restaurants, cafes, exhibition and dance halls |
| Industrial | As defined in the building regulations |
| Storage | Hazardous and Non-Hazardous |
| Miscellaneous | Not applicable, unknown, houses and flats not otherwise classified |

TABLE 3

ESTIMATED AVERAGE DIRECT FIRE LOSS

(Figures in £'000's at constant 1976 prices)

| No. | GROUP Description | AVERAGE LOSSES 1970 | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|---|
| 1 | Schools etc. | 2.94 | 3.73 | 3.69 | 5.73 | 6.93 |
| 2 | Offices | 2.38 | 2.79 | 4.73 | 1.68 | 3.03 |
| 3 | Hospitals etc. | a | a | 0.41 | 0.83 | 1.82 |
| 4 | Shops | 3.97 | 3.14 | 5.60 | 3.45 | 3.96 |
| 5 | Pubs and Restaurants | 1.99 | 2.57 | 2.54 | 2.75 | 2.32 |
| 6 | Hotels, Boarding Houses | 3.15 | 3.68 | 4.61 | 3.53 | 3.15 |
| 7 | Private Houses | 0.34 | 0.23 | 0.56 | 0.32 | 0.46 |
| 8 | Miscellaneous Non Industrial | 0.46 | 0.45 | 0.65 | 0.76 | 0.20 |
| 9 | Agriculture | 1.50 | 1.24 | 1.70 | 2.08 | b |
| 10 | Mining, Coal, Petroleum | a | 31.35 | 5.49 | 6.21 | b |
| 11 | Food, Drink & Tobacco | 7.62 | 10.30 | 14.83 | 20.42 | 17.23 |
| 12 | Chemicals and Allied Industries | 10.77 | 7.20 | 6.52 | 17.92 | b |
| 13 | Metal Manufacture | 3.41 | c | 4.12 | 1.83 | 2.58 |
| 14 | Mechanical Engineering | 9.47 | 7.94 | 9.41 | 7.42 | 6.59 |
| 15 | Instrument Engineering | a | 8.78 | 10.0 | 13.05 | 11.15 |
| 16 | Electrical Engineering | 18.52 | 19.97 | 15.25 | 34.21 | 21.61 |
| 17 | Shipbuilding | 5.35 | 6.99 | 5.19 | 5.32 | a |
| 18 | Vehicle Manufacture | 4.42 | 7.38 | 5.72 | 9.51 | 4.33 |
| 19 | Metal Goods Not Elsewhere | 7.96 | c | 6.70 | 6.80 | 5.18 |
| 20 | Textiles | 7.80 | 25.42 | 17.97 | 13.72 | 13.94 |
| 21 | Leather, Leather Goods & Fur | 6.57 | 8.93 | 6.91 | 12.07 | 6.31 |
| 22 | Clothing and Footwear | 18.74 | 21.82 | 13.25 | 23.15 | 16.13 |
| 23 | Bricks, Pottery, Glass, etc. | 3.94 | 8.90 | 3.38 | 8.12 | 5.82 |
| 24 | Timber, Furniture, etc. | 8.95 | 5.78 | 7.19 | 6.31 | 7.96 |
| 25 | Paper, Printing and Publishing | 17.58 | 17.85 | 9.91 | 14.46 | 11.43 |
| 26 | Other Manufacturing | 9.86 | 7.38 | 6.84 | 4.67 | 7.96 |
| 27 | Construction | 0.84 | 1.10 | 1.56 | 1.23 | 1.41 |
| 28 | Gas, Water, Electricity | 3.55 | 3.00 | 4.09 | 1.41 | b |
| 29 | Transport & Distributive Trades | 5.27 | 7.06 | 5.24 | 6.58 | b |
| 30 | Miscellaneous Service Industries | 2.37 | 1.79 | 2.33 | 3.00 | 2.40 |
| 31 | Public Administration | a | 1.08 | a | 2.93 | a |
| 32 | Miscellaneous Not in Buildings | 0.46 | 0.25 | 0.22 | 0.41 | b |
| | Overall Average | 1.71 | 1.64 | 1.78 | 1.82 | b |

a. Insufficient large fires to estimate annual loss.

b. Omitted as information on large 'not in building' fires unavailable.

c. Data unavailable.

TABLE 4

TOTAL DIRECT FIRE LOSS
(Figures in £$10^6$ at constant 1976 prices)

| No | GROUP Description | 1970 | | 1971 | | 1972 | | 1973 | | 1974 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total fires | Total loss | Total fires | Total loss | Total fires | Total loss | Total fires | Total loss | Total fires | Total loss |
| 1 | Schools etc. | 1822 | 5.35 | 1899 | 7.09 | 2153 | 7.96 | 2486 | 14.24 | 2444 | 16.95 |
| 2 | Offices | 1310 | 3.12 | 1272 | 3.55 | 1344 | 6.36 | 1432 | 2.41 | 1349 | 4.09 |
| 3 | Hospitals etc. | 1314 | a | 1473 | a | 1811 | 0.74 | 2170 | 1.80 | 2298 | 4.19 |
| 4 | Shops | 5066 | 20.11 | 4712 | 14.78 | 5375 | 30.09 | 5310 | 18.32 | 5026 | 19.91 |
| 5 | Pubs & Restaurants | 5451 | 10.86 | 5530 | 14.21 | 5991 | 15.23 | 6058 | 16.68 | 5608 | 13.02 |
| 6 | Hotels etc | 1366 | 4.30 | 1286 | 4.73 | 1531 | 7.06 | 1728 | 6.09 | 1745 | 5.49 |
| 7 | Private Houses | 45303 | 15.50 | 45955 | 10.84 | 52868 | 29.67 | 55482 | 17.63 | 55141 | 25.61 |
| 8 | Miscellaneous Non Industrial | 5791 | 2.64 | 5635 | 2.53 | 6463 | 4.23 | 6916 | 5.23 | 6431 | 1.32 |
| 9 | Agriculture | 6618 | 9.97 | 6544 | 8.13 | 7418 | 12.59 | 8262 | 17.23 | | b |
| 10 | Mining, Petroleum | 327 | a | 265 | 8.31 | 263 | 1.44 | 312 | 1.94 | | b |
| 11 | Food | 674 | 5.13 | 662 | 6.82 | 663 | 9.84 | 744 | 15.19 | 682 | 11.75 |
| 12 | Chemicals | 1146 | 12.35 | 1118 | 8.06 | 1054 | 6.87 | 1158 | 20.76 | | b |
| 13 | Metal Manufacture | 1101 | 3.76 | | c | 883 | 3.64 | 1156 | 2.12 | 1075 | 2.78 |
| 14 | Mechanical Engineering | 484 | 4.59 | 354 | 2.81 | 403 | 3.79 | 430 | 3.19 | 488 | 3.22 |
| 15 | Instrument Engineering | 59 | a | 52 | 0.46 | 50 | 0.50 | 68 | 0.74 | 57 | 0.64 |
| 16 | Electrical Engineering | 364 | 6.74 | 351 | 7.27 | 333 | 5.08 | 330 | 11.29 | 343 | 7.41 |
| 17 | Shipbuilding | 128 | 0.68 | 100 | 0.70 | 113 | 0.59 | 102 | 0.54 | 136 | a |
| 18 | Vehicle Manufacture | 772 | 3.42 | 579 | 4.27 | 676 | 3.87 | 646 | 6.15 | 566 | 2.45 |
| 19 | Metal Goods | 1017 | 8.09 | | c | 1000 | 6.70 | 1025 | 6.98 | 978 | 3.07 |
| 20 | Textiles | 1194 | 9.32 | 1082 | 27.50 | 1074 | 19.30 | 1232 | 16.91 | 1180 | 16.45 |
| 21 | Leather | 97 | 0.64 | 77 | 0.69 | 77 | 0.53 | 80 | 0.97 | 74 | 0.47 |
| 22 | Clothing | 259 | 5.11 | 244 | 5.32 | 260 | 3.44 | 256 | 5.93 | 260 | 4.19 |
| 23 | Bricks | 467 | 1.84 | 401 | 3.57 | 366 | 1.24 | 420 | 3.41 | 423 | 2.46 |
| 24 | Timber | 866 | 7.75 | 752 | 4.35 | 804 | 5.78 | 892 | 5.63 | 696 | 5.54 |
| 25 | Paper | 619 | 10.88 | 546 | 9.75 | 547 | 5.42 | 684 | 9.89 | 655 | 7.49 |
| 26 | Other Manufacturing | 625 | 6.17 | 607 | 4.48 | 646 | 4.42 | 764 | 3.56 | 657 | 5.23 |
| 27 | Construction | 2117 | 1.77 | 1907 | 2.10 | 2037 | 3.17 | 2086 | 2.56 | 1915 | 2.70 |
| 28 | Gas, Water, electricity | 1163 | 4.13 | 1282 | 3.85 | 1246 | 5.1 | 1226 | 1.73 | | b |
| 29 | Transport and Distrib Trades | 4970 | 26.2 | 4446 | 31.4 | 4630 | 24.2 | 4554 | 30.0 | | b |
| 30 | Miscellaneous Service Industries | 2223 | 5.26 | 2261 | 4.04 | 2398 | 5.58 | 2478 | 7.44 | 2411 | 5.79 |
| 31 | Public Administration | 1132 | a | 1216 | 1.32 | 1333 | a | 1518 | 4.44 | 1289 | a |
| 32 | Miscellaneous Not in Buildings | 26209 | 12.17 | 26995 | 6.84 | 30145 | 6.74 | 34136 | 13.96 | | b |
| | TOTAL LOSS | 121919 | 217 | 121511 | 222 | 135955 | 244 | 146142 | 275 | | b |

a Insufficient large fires to estimate annual loss

b Excluded as large 'not in building' fire data not available

c Data unavailable.

TABLE 5

YEARLY LOSS TOTALS COMPARED TO BIA ESTIMATES

(All figures at constant 1976 prices)

| YEAR | OUR ESTIMATE* £$10^6$ | BIA ESTIMATE £$10^6$ |
|---|---|---|
| 1970 | 217 | 238 |
| 1971 | 222 | 253 |
| 1972 | 244 | 259 |
| 1973 | 275 | 326 |

* Includes approximate estimates of losses in groups where insufficient large loss data is available for accurate calculation. (Note - these groups contribute no more than £6-7 million to the total.)

1974 figures are not shown as the large loss figures for the outdoor fires were not available to us at the time of analysis and total loss estimates could not therefore be produced.

TABLE 6

AVERAGE DIRECT LOSSES DUE TO FIRE IN 'STORAGE' AND 'NON-STORAGE' PREMISES

(Figures in £$10^3$ at constant 1976 prices)

| Industry Group | 1970 | | 1971 | | 1972 | | 1973 | | 1974 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage | Non Storage | Storage | Non Storage | Storage | Non Storage | Storage | Non Storage | Storage | Non Storage |
| Mining, Petroleum & Chemicals (SIC II, IV,V) | 44.2 | 6.6 | 41.3 | 9.6 | 29.6 | 4.9 | 19.5 | 7.7 | 35.1 | 8.0 |
| Engineering etc (SIC VII to XI) | - | - | 17.4 | 10.3 | 10.4 | 8.6 | 65.7 | 12.1 | 42.1 | 7.7 |
| Manufacturing (SIC XII to XIX) | 16.3 | 9.2 | 23.1 | 13.0 | 11.7 | 8.2 | 36.7 | 8.9 | 32.6 | 8.9 |
| Transport and Distribution (SIC XXII, XXIII) | 12.5 | 0.4 | 19.7 | 2.4 | 14.3 | 1.0 | 18.3 | 1.6 | 21.1 | 3.4 |
| All Industry | 12.1 | 4.9 | 18.5 | 6.4 | 6.3 | 6.5 | 8.8 | 6.6 | 11.2 | 6.4 |

NB 1. Non-storage fires are fires in all premises excluding offices, except for the Transport and Distribution Group where only 'Industrial' and 'Miscellaneous' fires are considered. (Buildings only )

2. Too few large fires to produce estimate of 1970 Engineering losses.

TABLE 7

ANNUAL FIRE LOSSES COMPARED TO ASSET VALUES
(All figures at 1976 constant prices)

| Industry Group | SIC | Estimated Loss (£10$^6$) | | | | | Assets (£10$^9$) | | | | | % of Assets Lost | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 70 | 71 | 72 | 73 | 74 | 70 | 71 | 72 | 73 | 74 | 70 | 71 | 72 | 73 | 74 |
| Food, Drink & Tobacco | 211-260 | 5.42 | 7.11 | 9.84 | 15.37 | 11.75 | 10.4 | 10.6 | 11.0 | 11.6 | 12.3 | 0.052 | 0.067 | 0.089 | 0.132 | 0.096 |
| Coal, Petroleum & Chemicals | 261-310 | 13.47 | 13.97 | 8.27 | 27.85 | 9.12 | 13.3 | 13.8 | 14.2 | 14.8 | 15.8 | 0.101 | 0.101 | 0.058 | 0.188 | 0.058 |
| Metal Manufactures | 311-330 | 6.71 | 5.42 | 9.00 | 3.62 | 4.33 | 12.8 | 13.1 | 13.5 | 13.8 | 14.6 | 0.052 | 0.041 | 0.067 | 0.026 | 0.030 |
| Engineering, Vehicles etc | 331-410 | 22.78 | 21.18 | 16.80 | 30.18 | 19.78 | 29.9 | 29.6 | 29.6 | 30.7 | 32.2 | 0.076 | 0.072 | 0.057 | 0.098 | 0.061 |
| Textiles, Clothing & Other Manufacturing | 411-499 | 46.19 | 54.47 | 39.69 | 47.53 | 41.86 | 21.5 | 21.8 | 22.2 | 23.0 | 24.4 | 0.215 | 0.250 | 0.179 | 0.207 | 0.172 |
| Distribution, Construction & Other Industries | 500-900 | 53.67 | 54.52 | 74.28 | 69.29 | 66.76 | 53.7 | 56.5 | 59.7 | 64.6 | 68.2 | 0.100 | 0.096 | 0.124 | 0.107 | 0.098 |
| All Industry | 211-900 | 149.7 | 157.5 | 158.3 | 194.9 | 153.6 | 141.6 | 145.5 | 150.2 | 158.5 | 167.5 | 0.106 | 0.108 | 0.105 | 0.123 | 0.092 |

Note: Losses for 1974 exclude those due to 'Not in Building' fires (and also Flixborough)

TABLE 8

LOSSES BY CAUSE OF IGNITION 1970

Total loss due to all causes £202.43 million (1976 prices)

| Cause | % of Total Loss due to Cause | | |
|---|---|---|---|
| | Zero Assignment | Proportionate Assignment | 1.5 Proportionate Assignment |
| Malicious/Doubtful | 12.0 | 23.5 | 30.0 |
| Children with Fire | 3.4 | 6.9 | 8.7 |
| Smoking Materials | 5.6 | 10.0 | 13.7 |
| Electrical Wiring | 4.4 | 8.5 | 10.5 |
| Other Electrical | 3.8 | 7.5 | 9.2 |
| Electrical Space Heating | 2.1 | 4.0 | 5.2 |
| Cooking | 1.8 | 3.7 | 4.6 |
| Other Gas | 0.8 | 1.6 | 2.0 |

TABLE 9

ESTIMATES OF TOTAL AVERAGE FIRE LOSSES IN THE TEXTILE INDUSTRY PRODUCED BY RAMACHANDRAN'S METHOD AND THE S.A.B. METHOD.

(Data from Rogers [4], used in both cases)

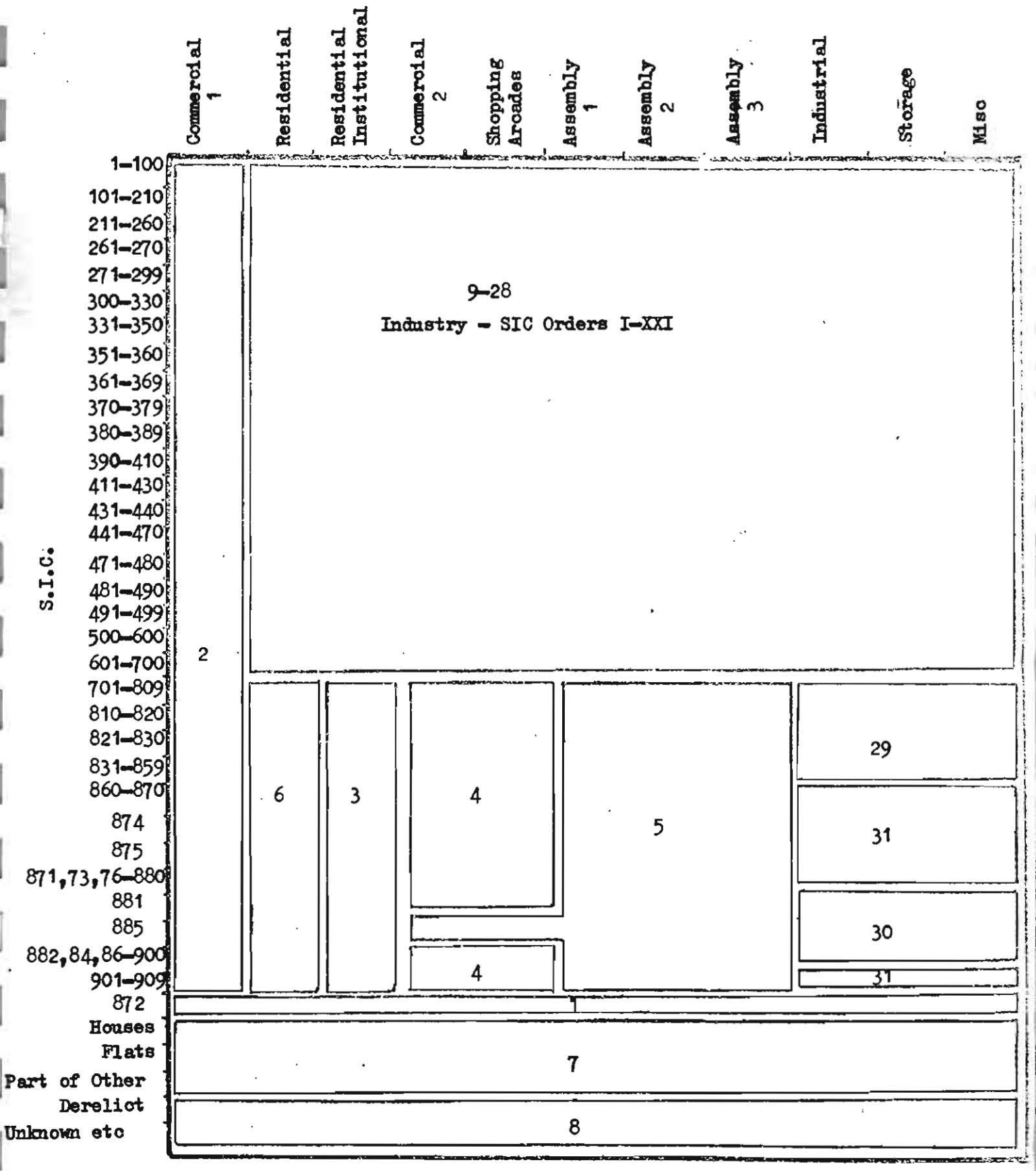
(Figures in £'000's at current year prices)

| Year | Method | |
|---|---|---|
| | Ramachandran | SAB |
| 1966 | 7.1 | 7.5 |
| 1967 | 9.3 | 9.7 |
| 1968 | 9.5 | 9.7 |
| 1969 | 12.4 | 12.7 |
| 1970 | 5.3 | 5.4 |
| 1971 | 19.2 | 19.5 |
| 1972 | 14.3 | 14.5 |

FIGURE 1

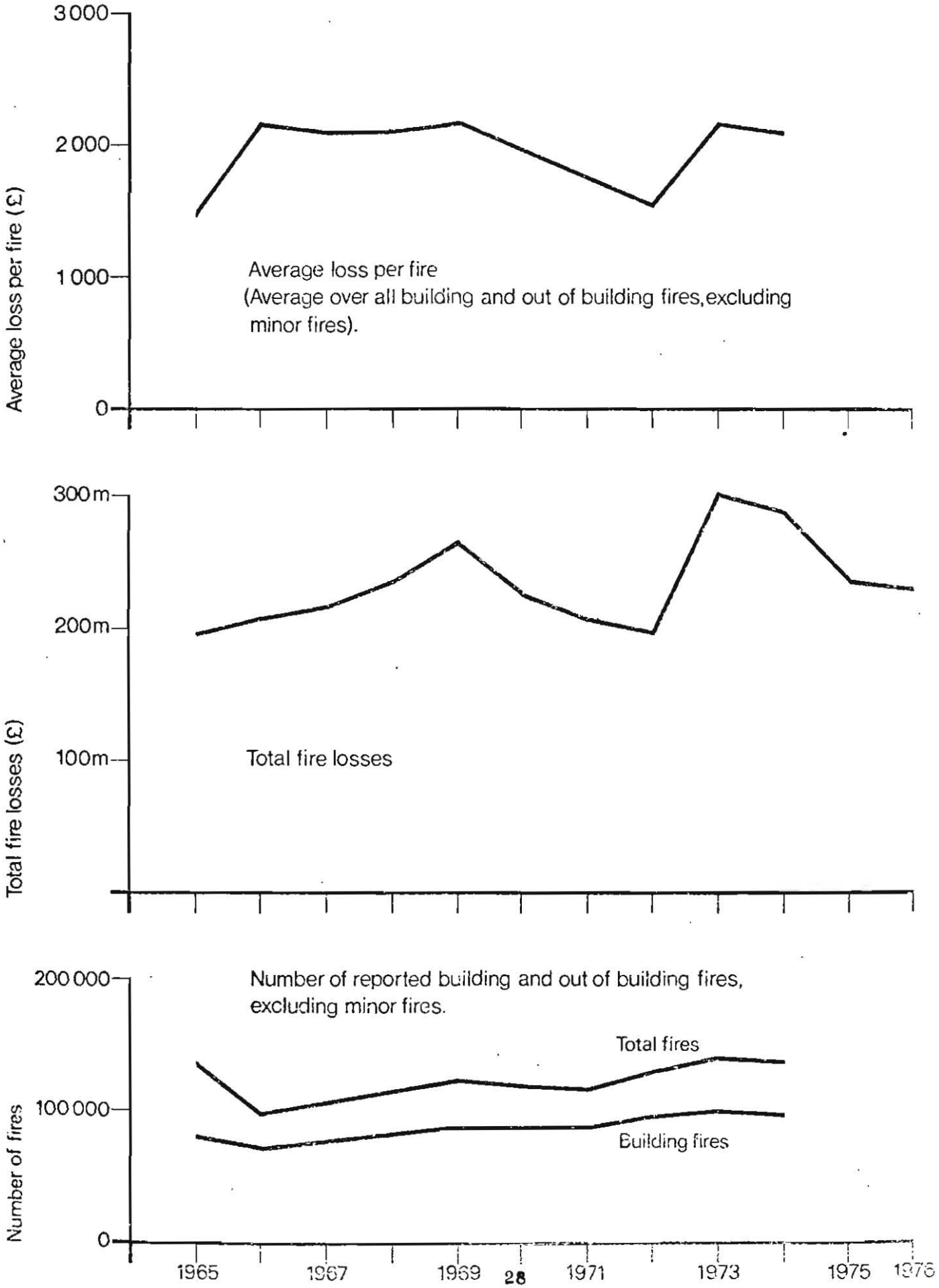
THE DEFINITION OF BUILDING CLASSES IN TERMS OF SIC AND BUILDING REGULATION GROUPS

BUILDING USAGE




Numbers in boxes represent Groups listed in Table 1

FIGURE 2. TOTAL FIRE LOSSES AND AVERAGE FIRE LOSSES FOR ENGLAND, SCOTLAND & WALES 1965-1976 – LOSSES SHOWN AT CONSTANT 1976 PRICES.



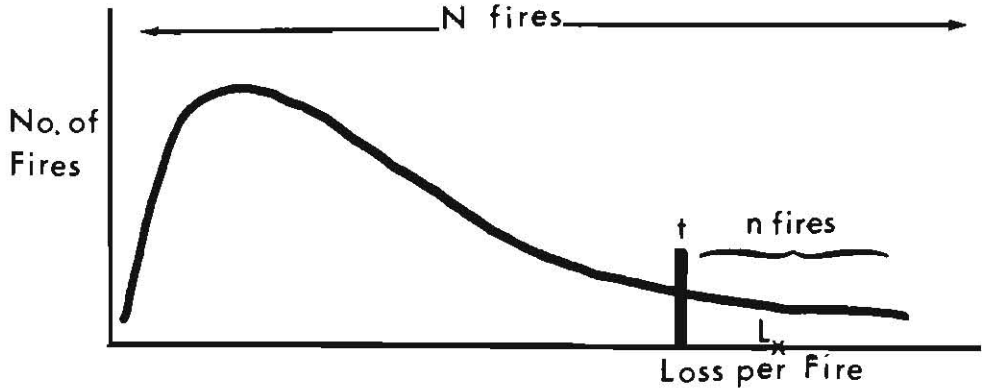
APPENDIX A

## Manual Method for Calculating Average Losses - The Hazard Function Method

Using the method below, the average loss for any group of fires may be found from 4 items of information:-

1. The total number of fires (N)
2. The number of large fires (n)
3. The average loss in the large fires (L)
4. The size of loss above which a fire is considered to be large (t)

Assuming a log-normal distribution of fire losses, these figures are related as shown below.

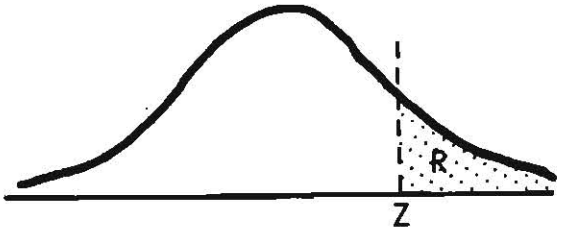



To find the average loss:-

1. Find the proportion of all fires in the group which are large fires(R)

   $R = n/N$ - (1)

2. From normal distribution tables find the standardised normal variate Z which corresponds to an area R in the tail of the standard normal distribution.



3. Calculate

$$Y = \frac{h\,(Z) \times t}{L} \quad - (2)$$

where h (Z) is the hazard function tabulated (see Table A.1), corresponding to the value of Z found above.

4. From the hazard function tables find the value of U such that

$$h\,(U) = Y \quad - (3)$$

5. Then

$$Z - U = S \quad - (4)$$

$$LN\,(t) - Z \times S = M \quad - (5)$$

S and M are the two parameters of the log-normal distribution needed to calculate the average loss.

6. Average Loss = $E \times P\,(M + \frac{1}{2} S^2)$ - (6)

Example

Total No of Fires (N) = 4000
No of large fires (n) = 91
Average Loss in Large Fires (L) = £38,450
Cut off Point = £10,000
R = 91/4000 = 0.02275

From Normal tables
Z = 2.0
From Table A.1
h(Z) = 2.373

$$y = \frac{2.373 \times 10,000}{38450} = 0.6172$$

From Table A.1
U = - 0.3
Therefore S = 2.3
M = 4.6

AVERAGE LOSS = $EXP(4.6+\frac{1}{2}(2.3)^2)$ = £1400

Appendix A

TABLE A.1

THE HAZARD FUNCTION

The function tabulated is h(x), where h(x) is the hazard function $F'(x)/(1-F(x))$. F(x) is the standardised cumulative normal distribution function.

| X | -2.0 | -1.0 | -0.0 |
|---|---|---|---|
| - 0.0 | .0552 | .2876 | .7979 |
| - 0.1 | .0448 | .2520 | .7353 |
| - 0.2 | .0360 | .2194 | .6751 |
| - 0.3 | .0286 | .1897 | .6172 |
| - 0.4 | .0226 | .1629 | .5619 |
| - 0.5 | .0176 | .1388 | .5092 |
| - 0.6 | .0136 | .1173 | .4591 |
| - 0.7 | .0105 | .0984 | .4119 |
| - 0.8 | .0079 | .0819 | .3676 |
| - 0.9 | .0060 | .0676 | .3261 |

| X | 0.0 | 1.0 | 2.0 |
|---|---|---|---|
| 0.0 | .7979 | 1.525 | 2.373 |
| 0.1 | .8626 | 1.606 | 2.462 |
| 0.2 | .9294 | 1.688 | 2.551 |
| 0.3 | .9982 | 1.770 | 2.641 |
| 0.4 | 1.069 | 1.854 | 2.732 |
| 0.5 | 1.141 | 1.939 | 2.823 |
| 0.6 | 1.215 | 2.024 | 2.914 |
| 0.7 | 1.290 | 2.110 | 3.006 |
| 0.8 | 1.367 | 2.197 | 3.098 |
| 0.9 | 1.446 | 2.285 | 3.190 |

APPENDIX B

Method of Assessing Industrial Asset Values

The asset value of an industry was defined as the total value of its buildings, plant and machinery, vehicles and stocks. To obtain agreement with BIA loss figures, gross (full replacement) or net (written down) values were used for different assets, as follows:

| Asset | Asset Measurement |
|---|---|
| Buildings | GROSS |
| Plant<br>Machinery<br>Vehicles<br>Stock | NET |

Gross capital stock of building was obtainable directly from table 12.14 in the National Income and Expenditure Accounts. The net value of stocks (and work in progress) for any year was found by working back from the 1975 level using Table 13.3 in the Accounts.

The net capital stock of other assets was not available on an industry by industry basis. The following method was used to calculate this figure.

1. Find the total net industrial stock of plant and vehicles for the year from table 12.11 and convert to 1970 prices.

2. Subtract this from the total gross industrial stock of plant and vehicles in table 12.14, call the figure obtained $\Delta$.

3. Net capital stock of plant, machinery and vehicles for an industry is then:-

$$\text{Gross Plant and Vehicles} - \left( \frac{\text{Gross Plant and Vehicles}}{\text{Total gross plant and vehicles for all industries}} \right) \times \Delta$$